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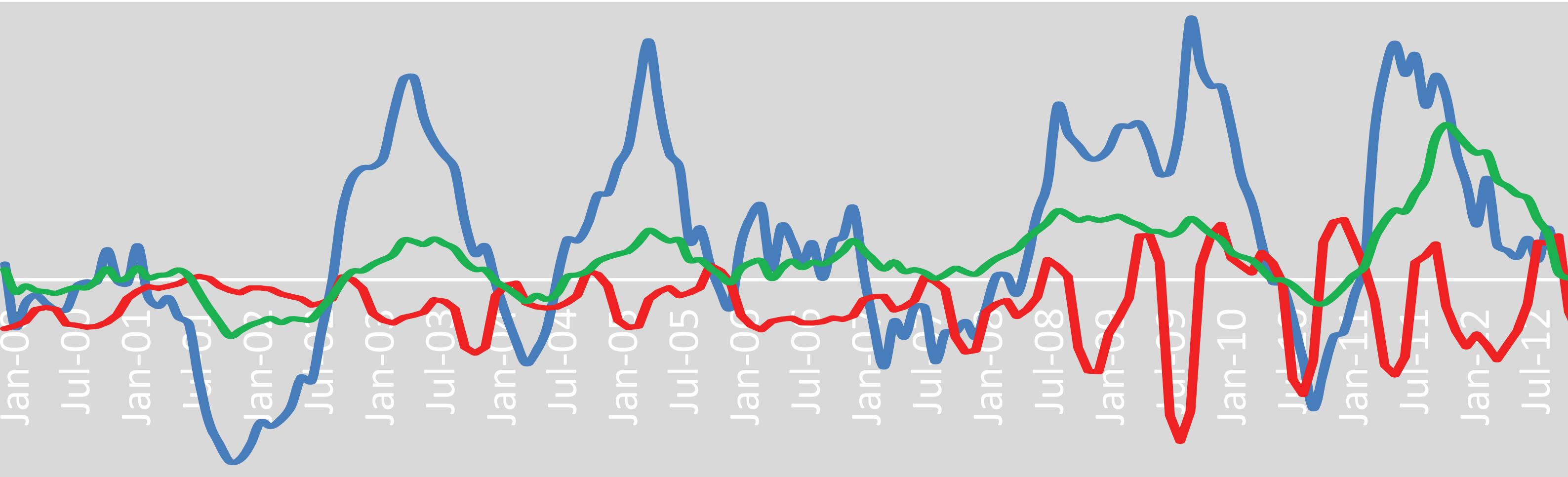

INFLATION DYNAMICS AND AGRICULTURAL SUPPLY SHOCKS IN UGANDA

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ABSTRACT

We estimate the contribution of agricultural supply shocks to inflation in Uganda. Using monthly data for the time period January 2000 to December 2012, we develop an empirical model for inflation processes in Uganda. The model is estimated as a single equation that includes lagged vector error correction terms from the money, external, and domestic agricultural markets. We include in our model a measure for shocks to the agricultural sector, the agricultural output gap, estimated as the monthly deviations of realized from potential agricultural output. The analysis is augmented by a VAR model that allows us to account for inflation persistence. Results indicate that disequilibria in the money, external and agricultural sectors feed into the Ugandan inflation process in the long run. Importantly, the agricultural sector is one of the important sources of inflation in the short run. Our findings have important implications for policy in Uganda. Specifically, policies geared towards improving agricultural productivity on the one hand and limiting supply rigidities on the other will be crucial in controlling inflation in Uganda

Keywords: Inflation, agricultural shocks, money market, external sector, energy sector

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1. INTRODUCTION

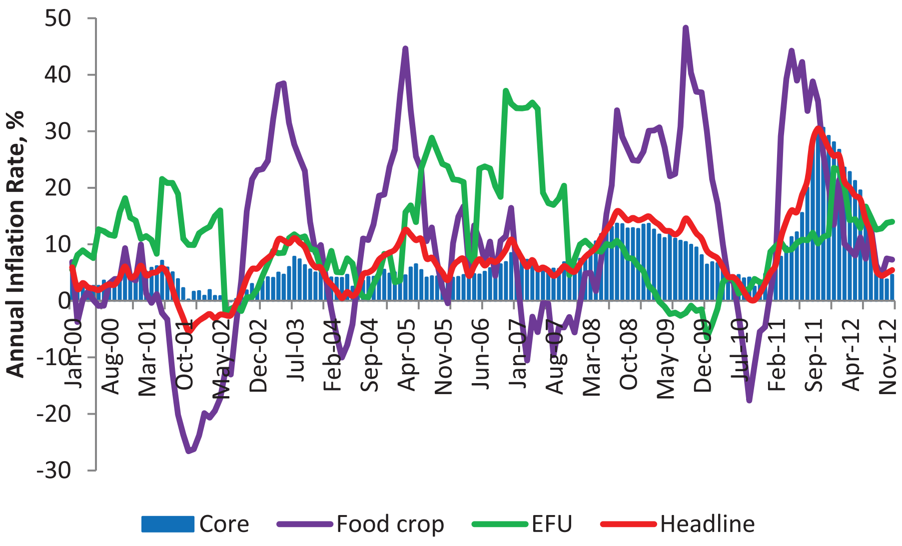
Uganda has recorded impressive economic growth averaging 7 percent per year over the last two decades. Such growth has been on account of sustained political stability and sound macroeconomic management policies that ensured price stability and investor confidence. Indeed, Uganda has experienced relatively low and stable inflationary rates for the last two decades (Adam, 2009). However, in the recent past, Uganda has experienced episodes of high and volatile inflationary pressures. The first spike occurred in 2008 (figure 1), when inflation levels rose to 15.9 percent from under 5 percent within a year, and was reportedly due to the effects of the global financial crisis and increasing world prices for food and fuel.

The second spike happened in 2011 and was mainly attributed to supply side constraints particularly the drought that affected the local agricultural economy. During the second spike, inflation rose from 0.13 percent in October 2010 to 15.73 by June 2011. It peaked at 30.5 percent in October 2011 before going to a downward trajectory. By December 2012, inflation was reported at 5.5 percent.

Clearly, Uganda's recent inflation experiences have been more elevated, even when compared to its regional neighbours in the East African Community (figure 2). For the two years between January 2011 and December 2012 inflation averaged 16.6 percent in Uganda, while it averaged 6.7 percent in Rwanda, 11.8 percent in Kenya and 14.4 percent in Tanzania.

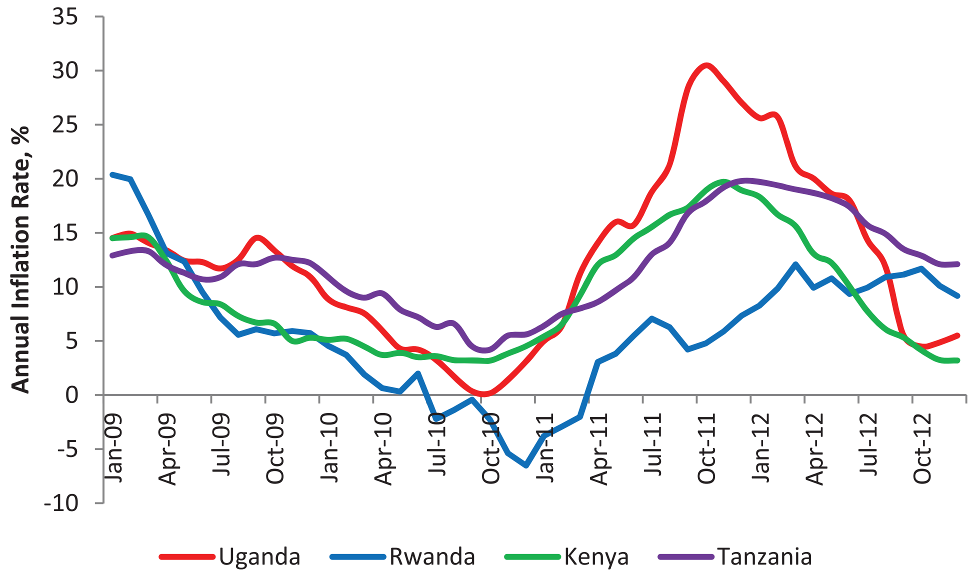
In light of the inflationary surge, the Bank of Uganda responded by pursuing a tight monetary policy, having adopted a policy change to inflation targeting regime. The Central Bank Rate (CBR) was introduced in July 2011 as a benchmark interest rate that

Figure 1: the evolution of inflation and its components



Source: Bank of Uganda Statistics

Figure 2: Regional inflationary experiences



Sources: Bank of Uganda, National Institute of Statistics of Rwanda, Kenya National Bureau of Statistics, and Bank of Tanzania.

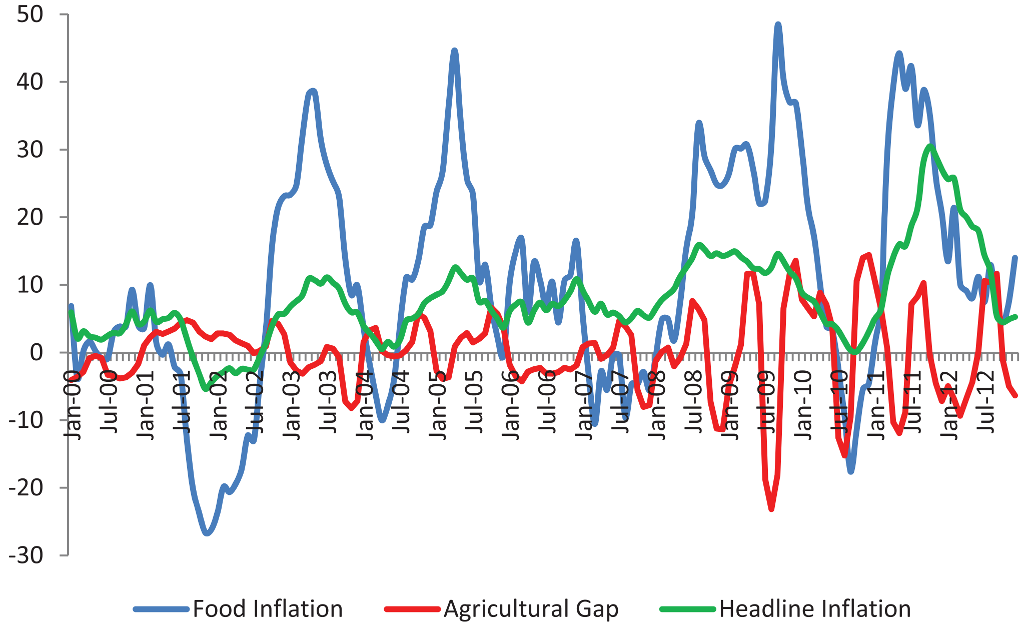
was intended to influence other interest rates such as the lending and deposit rates that would in turn feed into changes in aggregate demand. Inflation rates returned to single digits by September 2012.

While anecdotal evidence links the recent inflationary surge in Uganda to local supply side factors, particularly in agriculture (see for example Mugume 2011; Mawejje and Bategeka 2011; Mukiza 2011), there is limited empirical research to estimate the contribution of agricultural shocks to overall inflation in Uganda. Indeed, inflation and the agricultural output gap follow counter cyclical patterns (figure 3) indicating that variations in food production feed into food and headline inflation.

The purpose of this paper, therefore, is to estimate the determinants of inflation in Uganda, highlighting the possible feed-through effects emanating from supply shocks in the domestic agricultural sector.

Earlier studies on inflation in Uganda did not fully account for the potential role of supply side constraints in agriculture. Such studies tended to model inflation as emanating from the demand side through disequilibrium in the money and external markets (see for example Muwonge and Obwona 2003; Abuka and Wandera 2001; Nachenga 2001; Barungi 1997). Only Kihangire and Mugyenyi (2005) and more recently Kabundi (2012) have tried to model Uganda inflationary processes taking into account shocks to the agricultural sector. While Kihangire and Mugyenyi (2005) used rainfall data as a proxy for the agricultural supply shocks, Kabundi (2012) used cereal production as a proxy for agricultural output. These approaches provide good insights into the potential role of agricultural output variability to inflation, but they are not without flaws: the agricultural output gap can arise for other reasons other than rainfall – for example crop failure may arise due to covariate pests or hailstorm shocks. Moreover, the relationship between rainfall and agricultural production may be non-linear, implying that more than "optimal" rainfall may be detrimental to agricultural

Figure 3: Inflation and the agricultural output gap



Source of data: Bank of Uganda

production. In addition, cereal production as a proxy for agricultural production may underestimate agricultural output for a country like Uganda that depends on a variety of other food crops. This paper makes use of actual agricultural output data to correct these flaws.

The paper follows the work of Durevall et al (2013), Adam et al (2012), Kinda (2011), and Diouf (2007) who all modeled inflation as emanating from disequilibrium in three sectors: the money market, the external sector, and the energy sector for Ethiopia, Tanzania, Chad and Mali respectively. This paper extends these approaches to incorporate the agricultural sector.

The specific objective of the paper is to estimate the contribution of agricultural supply shocks to inflation in Uganda by incorporating agricultural shocks in the model. This paper provides new insights into both the short run and long run determinants of inflation in Uganda. This is especially important given that recent developments seem to indicate Uganda's inflation has been rising at a rate higher than the regional averages. In addition this paper contributes in the development of a coherent empirical framework for the analysis of inflationary trends in the economy. In particular, the paper seeks to develop a sound econometric framework for modeling inflationary processes in Uganda with a view guiding the policy decisions of the monetary and fiscal authorities.

The rest of the paper is organized as follows: Section two discusses the literature and analytical framework; section three presents the estimation strategy and the data; section four presents and discusses the results; section five provides the conclusions and policy recommendations.

2. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

2.1 Literature review

2.1.1 Why is it important to study inflation?

Studies of inflation and its determinants have dominated macroeconomic debates in the past decades because of the importance of price stability in economic growth and household welfare. The major conclusions from those studies are that: high inflation is detrimental to investment and growth; erodes the purchasing power; reduces household welfare; and exacerbates income inequality.

Using panel data from over 100 countries in the time period 1960 to 1990, Barro (1996) provided insights into the relationship between inflation, growth and investments. In particular, he was able to show that increasing the average inflation rate by 10 percentage points would lower the growth rate of real GDP per capita and investments by an average of 0.2 - 0.3 and 0.4 percentage points respectively. It is now widely acknowledged that inflation affects growth in the long run (Fernandez 2003; Bruno and Easterly 1998) albeit with a non-linear relationship (Yilmazkuday 2013; Pollin and Zhu 2006; Khan and Senhadji 2001). This implies that there are threshold values below which inflation is desirable and above which it is detrimental to economic performance.

In addition, numerous studies have tried to explore the mechanisms through which inflation would affect long run growth. Boyd et al (2001) used cross-sectional as well as panel GMM methods to highlight the impact of sustained inflation on financial sector performance and therefore long run growth. They show that inflation is negatively associated with financial sector lending to the private sector, the quantity of bank assets and the volume of bank liabilities. This finding is similar to earlier findings by Hubens and Smith (1999).

Bulir (2001) studied the implications of inflation for the distribution of income using a cross-country dataset of 75 countries. Inflation was shown to lead to higher income inequality especially in hyper-inflation countries, highlighting the non-linear relationship between inflation and income inequality.

For agricultural households, the effects of inflation are usually felt through the increase in food prices. Ulimwengu and Ramadan (2009) showed that the effects of increasing food prices vary between net sellers and net buyers of food. Specifically, increasing food prices affect household welfare through reduced consumption and increasing income for net buyers and sellers respectively. However, substitution effects imply that food consumption falls across both categories of net sellers and buyers. These results suggest adverse implications of increasing food prices for household welfare.

2.1.2 The determinants of inflation

Barungi (1997) offers some of the first empirical insights of the determinants of inflation in the Ugandan post reform era. While she acknowledges the importance of supply side shocks, she models inflation as a purely macroeconomic problem that is dependent on money growth and exchange rate movements. Her research findings show that inflation is driven by money supply growth in the medium to long term.

Abuka and Wandera (2001) used the Box-Jenkins ARIMA approach augmented by the Engel-Granger two –step error correction procedure to model Uganda's inflation. They show that real GDP expansion dampens Uganda's inflation, while nominal money growth and exchange rate depreciation were shown to be positively associated with inflation.

Using elaborate econometric analyses, Nachenga (2001) investigated the relationships among money, prices, income and interest rates in Uganda during the time period 1982-1998. They show that there is a long run relationship between inflation, the monetary and external sectors. Similar results are obtained by Muwonge and Obwona (2003). The above literature survey indicates the importance of monetary factors in inflation processes.

The alternate view that inflation may not always be a monetary phenomenon in Uganda was investigated by Kihangire and Mugyenyi (2005). Using ARDL-ECM methods they show that there is insufficient evidence to conclude that non-monetary factors are the major drivers of inflation. Separately, Kabundi (2012) showed that shocks to cereal production have long term effects on inflation in Uganda.

Interest in the contribution of agricultural supply shocks to inflation processes, particularly in agrarian economies, is gathering pace. In sub-Saharan Africa, evidence about the importance of agricultural supply in inflation processes has been provided by among others; Durevall et al (2013) for Ethiopia; Kinda (2011) for Chad; Adam et al (2012) for Tanzania, and Diouf (2007) for Mali. This paper builds on such studies to model inflation processes for Uganda.

2.2 Analytical framework

Traditionally, inflation is modeled using the well known quantity theory of money and the Philips curve. The quantity theory of money postulates that excessive money supply will lead to inflationary pressures in an economy. The quantity theory of money has been widely used by researchers who model inflation as a purely monetary phenomenon. Such researchers do not emphasize the roles that supply side factors such as shocks to agricultural production play in determining domestic inflation. However, recent research in many developing countries, especially in sub Saharan Africa, have shown food supply shocks to have significant implications for inflation (see for example Adams et al 2012; Kinda 2011; Durevall at al 2013; Diouf 2007).

The Philips curve postulates that excessive aggregate demand creates employment which feeds into higher wages and later inflation. However, various scholars (see for example Durevall et al 2013; Kinda 2011) have argued that because of the informality of the labour markets in agrarian economies and the pervasiveness of subsistence production, the Philips curve may not provide the appropriate theoretical framework for modeling inflation dynamics for developing countries. We, therefore, consider the Philips curve theory not appropriate for modeling inflation in Uganda.

We thus proceed to model inflation in the context of a small open economy, where the general price level is a weighted harmonic average of tradable prices P_t^T and non-tradable prices P_t^{NT} such that

$$P_t = P_t^{T\alpha} P_t^{NT(1-\alpha)} \quad 1)$$

This can be expressed in natural logarithms as

$$P_t = \alpha P_t^T + (1-\alpha) P_t^{NT} \quad 2)$$

Assuming purchasing power parity (PPP), where Uganda is a price taker, the price of tradables is determined in the international market through the exchange rate channel and foreign prices.

$$P_t^T = f(P_t^*, E_t) \quad 3)$$

Where P_t^* measures the price of imported goods and services; and E_t is the exchange rate.

The price of non-traded goods is determined in the money market such that real money demand equals real money supply, such that,

$$\frac{M_t^s}{P_t} = \frac{M_t^d}{P_t} \quad 4)$$

The above expression can been converted to natural logarithm form as

$$m_t^s - p_t = m_t^d - p_t \quad 5)$$

Where; m_t^s represents broad money supply, m_t^d represents money demand, and p_t represents the general price level, represented by the consumer price index. But real money demand can be modeled as a function of output, the opportunity cost of holding money and inflation expectations. And if we assume that inflation expectations depend on past inflation, then we can model inflation in the non-tradable sector as a function of broad money, m_t real output, $y_t - p_t$, the opportunity cost of holding money r_t and past inflation realizations, p_{t-1}, such that the empirical estimation of domestic prices can be expressed as

$$P_t^{NT} = f(m_t, y_t - p_t, r_t, p_{t-1}) \quad 6)$$

We expect broad money and real output to be positively correlated with inflation as higher real incomes increase the transactional demand for money balances. We expect the opportunity cost of holding money to be negatively related to inflation, as higher rates of return on financial assets is expected to reduce demand for money holding. Substituting equations 3 and 6 into equation 1, we get the following inflation model to be estimated:

$$p_t = f(m_t, y_t - p_t, r_t, p_{t-1}, e_t, p_t^*) \quad 7)$$

We expect exchange rate depreciation to lead to inflation as local currency equivalent of import prices rises. All other a priori expectations remain unchanged.

Domestic Food supply conditions and food price inflation

Finally, we augment the model with structural factors that we think could fuel inflation. In particular, we include variables that capture variability in agricultural production and transportation costs. Such variables could include a measure of the agricultural output gap as demonstrated by Durevall et al. (2013) for Ethiopia, and rainfall data as shown by Adam et al (2012) and Diouf (2007) for Tanzania and Mali respectively. The variables that capture transportation costs include may include the fuel prices as demonstrated again by Adam et al (2012) for Tanzania.

In this paper, using the Hodrick-Prescott filter technique, we adopt the agricultural output gap as a measure of agricultural supply shocks. We use the quarterly series of agricultural GDP interpolated to monthly series. The gap is computed as the deviations of realized output from potential output where the latter represents output under normal conditions. As such a positive gap indicates production above potential and a negative gap indicates production below potential.

$$y_t^a = yp_t^a + gap_t \qquad 8)$$

Where y^a is realized agricultural output; yp_t^a is potential output; and gap_t is the output gap. Clearly the output gap can be expressed as the difference between realized and potential output. However, output gap measures tend to have some theoretical and empirical shortcomings and results should be discussed with caution. Indeed, the unobserved nature of potential output makes the output gap susceptible to measurement errors and uncertainty as discussed by Nelson and Nikolov (2004).

Finally, the Uganda agricultural calendar is such that it has two distinctive rainy and dry seasons, each spanning approximately three months (one quarter). We use quarterly dummy variables to capture the seasonal effects due to rainfall and other seasonal factors.

3. ESTIMATION STRATEGY AND DATA

3.1 The estimation strategy

3.1.1 The vector error models

As a first step, we develop separate vector error correction models for the four sectors, namely: the money market, the external sector, the agricultural sector and the energy sector. The vector error correction models take the following general form:

$$\Delta x_t^i = \pi^i + \alpha\beta' x_{t-1}^i + \sum_{j=1}^{k} \emptyset_i \Delta x_{t-j}^i + \varepsilon_t^i \qquad 9)$$

Where; $i = (1,2,3,4)$ represents the money market, the external sector, the agricultural sector and the energy sector; $x$is is a vector of I (1) variables; is the adjustment parameter, β is a matrix of long-run coefficients, $\emptyset_i$ are the short run coefficients π, is a vector of constants. It then follows that $\alpha\beta' x_{t-1}^i$ represents the stationary error correction terms, which define the deviations from long run equilibrium in the sectors.

We obtained the long run equilibrium relationship for each sector in the following sequence: we estimate the vector auto regressive model and obtain the optimal lag length in the first step. The optimal lag lengths were selected following standard criteria including the likelihood ratio (LR) test, the Schwarz criterion (SC), the final prediction error (FPE), the Hannan-Quinn (HQ) criterion, and the Akaike information criterion (AIC). The second step involves determining the number of co-integrating relationships in the long run matrices $\alpha\beta' x_{t-1}$ following the Johansen (1988) procedure. This was followed by estimation of the unrestricted co-integrating relation in the vector error correction model (based on equation 9) and tests of hypotheses (or imposition of implied restrictions) to determine the long run equilibrium relationship in the third step. The statistical significance of the hypothesis tests was provided by the Chi-squared statistic. In the final step, model stability and residual analysis was undertaken to check for normality, autocorrelation and heteroskedasticity of the residuals.

3.1.2 The single equation inflation model

We estimate the single inflation model using ordinary least squares method. The model includes both short run and long-run determinants of inflation. The specific variables that enter the inflation model include all the variables used in the estimation of sector specific vector error correction models. All variables included are stationary or transformed to be so. The model includes the lagged error correction terms generated from the money, external, energy and agricultural sectors and the first differences of all variables used in the long run vector error correction models. Importantly for this paper, the model includes the lagged values of the agricultural output gap to control for supply related shocks in the agricultural sector. In addition, various dummy variables that capture important historical events of significance to the Uganda inflation processes including the global financial crisis (GFC), a change of policy regime from targeting monetary aggregates to inflation targeting (IT) are included. The model also includes four quarterly dummies to control for the potential seasonality in inflation.

The single equation error correction inflation model that includes long run equilibrium terms derived from the four sectors is shown in equation 10 below:

$$\Delta LCPI_t = \beta_0 + \sum_{j=1}^{k} \beta_{1j} \Delta LCPI_{t-j} + \sum_{j=1}^{k} \beta_{2j}^{i} \Delta x_{t-j}^{i} + \sum_{j=1}^{k} \beta_{3j}\, gap_{t-j} + \sum_{j=1}^{k} \theta_j d_t + \emptyset_1 Em_{t-1} + + \emptyset_2 Ee_{t-1} + + \emptyset_3 Ea_{t-1} + \emptyset_4 Ef_{t-1} + \varepsilon_t \qquad 10)$$

Where Δ and L are the difference and natural logarithm operators respectively; CPI_t is the consumer price index; and x_t is a vector of variables that include the opportunity cost of holding money, the exchange rate variable, foreign prices that include different indices for the international prices for food and crude oil, domestic GDP, and fuel price. In addition, gap_t is the agricultural output gap; d_t is a vector of dummy variables included in the model, E_m,E_e, E_a, and, E_f, are error correction terms from the money, external, agricultural and energy sectors respectively, included in their lagged forms. The data, except the agricultural output gap and the treasury bill rates, are transformed and used in their natural logarithm form.

In estimating the model in equation 10 above we followed the general-to-specific approach to arrive at a parsimonious representation of the Uganda inflation process. The full model included up to twelve lags which were reduced in search of a parsimonious model as explained earlier.

3.1.3 Vector Auto Regressive (VAR) Model

In addition to the single equation inflation model, we estimate a vector auto regressive (VAR) model that can more ably handle the possible interactions among variables that could affect the estimated coefficients in the single equation model. Of interest to this paper, after estimating the VAR we undertake Granger non-causality tests to make inferences on the direction of causation among the variables. This is augmented by impulse response functions analyses to investigate the direction of inflation response to various shocks and the relative importance of such shocks in determining inflation.

Following Maddala and Kim (2004), the VAR model for variables takes the expression below:

$$Y_t = A(L)Y_t + \mu_t \qquad 11)$$

Where L is the lag operator,
$Y_t' = (y_{1t}, y_{2t}, \dots, y_{kt})$ and
$A' = (A_1, A_2, \dots, A_p)$ are kxk matrices and
μ_t is a k-dimensional vector of errors, with
$E(\mu_t) = 0$

3.2 Data

The study uses a 13 year period (2000-2012) monthly dataset that allows us to generate a fairly long time series with 156 data points for each variable. Uganda specific data were obtained from the Bank of Uganda (BOU) and the Uganda Bureau of Statistics (UBOS). The international food prices data were obtained from the Food and Agricultural Organization of the United Nations (FAO), and the international fuel prices data were obtained from the international energy agency (IEA). The specific data that we use is as follows: LCPI is the natural logarithm of the consumer price index; LCORE is the natural logarithm of the core price index; LFOOD is the natural logarithm of the domestic food price index; LEFU is the natural logarithm of the energy, fuel and utilities price index; LM2 is the natural logarithm of money supply; TB is the 91-day treasury bill rates; LXRATE is the natural logarithm of the nominal exchange rate; LPCY is the natural logarithm of per capita output; LFAO is the natural logarithm of the FAO index; LCRUDE is the natural logarithm of the fuel price index; LAGRIC is the natural logarithm of agricultural GDP; and GAP is the agricultural output gap; GFC is the global financial crisis dummy variable; and IT is the inflation targeting dummy variable. Table 1 below shows the descriptive statistics of the data

Table 1: Descriptive statistics of the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
LCPI	156	4.689	0.316	4.202	5.297
LCORE	156	4.708	0.277	4.313	5.284
LFOOD	156	4.618	0.479	3.723	5.486
LEFU	156	4.667	0.405	3.921	5.283
LPCY	156	10.718	0.146	10.476	10.960
LXRATE	156	7.562	0.142	7.322	7.942
LM2	156	7.954	0.670	6.913	9.087
GAP	156	0.054	6.289	-23.2	14.416
LAGRIC	156	5.457	0.077	5.243	5.604
TB	156	9.836	4.314	2.968	20.351
LCRUDE	156	3.968	0.561	2.929	4.888
LFAO	156	4.911	0.334	4.445	5.472
GFC	156	0.340	0.475	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
IT	156	0.115	0.320	0	1
Quarter two dummy	156	0.250	0.434	0	1
Quarter three dummy	156	0.250	0.434	0	1
Quarter four dummy	156	0.250	0.434	0	1

The graphical expositions in appendix 1 indicate that all variables, save for the agricultural output gap (GAP) and treasury bill rates are not stationary. This was confirmed by the augmented Dickey-Fuller and Phillips-Perron tests that indicated that the agricultural output gap is stationary in levels, I(0), while the rest of the variables are integrated of the first order, I(1). As shown in table 2 below:

Table 2: Stationarity tests

Variable	Unit roost test statics in levels		Unit roost test statics in first difference		Order of Integration
	ADF	Philips Perron	ADF	Philips Perron	
GAP	-4.894***	-4.189***			I(0)
LCPI	0.184	0.891	-8.671***	-8.196***	I(I)
LCORE	1.628	1.931	-8.063***	-8.089***	I(1)
LEFU	-0.634	-0.612	-11.845***	-11.884***	I(1)
LFOOD	-1.175	-0.861	-8.504***	-11.071***	I(1)
LFAO	-1.172	-0.892	-4.926***	-7.075***	I(1)
LXRATE	-0.451	-0.904	-8.509***	-8.438***	I(1)
TB	-2.650*	-2.962**			I(0)
LM2	0.375	0.434	-11.581***	-16.031***	I(1)
LCRUDE	-1.162	-1.167	-10.221***	10.229***	I(1)
LPCY	-0.700	-0.637	-8.707***	-8.186 ***	I(1)
LAGRIC	-2.740*	-2.720*	-8.597***	-8.095***	I(1)

Saharan countries including Uganda (see for example Nachenga 2001). Following such studies we model the Uganda money market in equation 12 below:

$$lm2_t = \beta_0 + \beta_1 lpcy_t + \beta_2 tb_t + \beta_3 lxrate_t + \varepsilon_t \qquad 12)$$

The demand for money is assumed to be increasing in output per capita, $lpcy$; and exchange rate depreciation, $lxrate$; while reducing with the opportunity cost of money, tb.

4. RESULTS AND DISCUSSIONS

4.1 The money market

The determinants of money demand in Uganda have been well researched. Recent studies indicate that the exchange rate, output per capita, and the opportunity cost of holding money are important determinants of money demand for sub

In estimating the long-run money market equilibrium in equation 12 above, the various lag selection criteria including the LR, FPE, AIC, and HQIC point to an optimal lag length of 4. The SBIC indicated an optimal lag length of 2 as shown in table 3 below. In the estimation of the model, we applied a lag length of 4.

Table 3: lag length selection criteria for the money market

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-77.98			0.00	3.5e-05	1.08	1.62	1.67
1	817.62	1791.2	16	0.00	3.3e-10	-10.49	-10.32	-10.09
2	886.50	137.76	16	0.00	1.6e-10	-11.11	-10.83	-10.40*
3	912.03	51.06	16	0.00	1.7e-10	-11.24	-10.82	-10.21
4	965.71	107.35*	16	0.00	8.7e-11*	-11.82*	-11.27*	-10.47

The Johansen co-integration procedure does not reject the null hypothesis of one cointegrating vector (table 4). We are therefore confident that there could be one cointegrating relationship that explains the long-run equilibrium in the money market.

The error correction term (ec_money) that represents the long-run disequilibrium shows that there is a long-run relationship between money supply, exchange rates, treasury bill rates and the level of national output per capita. This relationship is expressed in equation 13 and table 5 below.

Table 4: the Johansen tests for cointergration in the money market.

Maximum rank	Number of parameters	LL	Eigen value	Trace statistic	5% critical value
0	52	938.44		54.3081	47.21
1	59	952.78	0.171	26.6360*	29.68
2	64	963.39	0.130	6.4202	15.41
3	67	966.59	0.041	0.0022	3.76
4	68	966.60	0.000		

$$ec_{money} = m_t - 1.064lxrate_t + 0.041tb_t - 3.845lpcy_t + 40.753 \quad 13)$$

Table 5: Long-run equilibrium in the money market

Variable names	Coefficient	Standard Error	Z value
LM2	1		
LXRATE	-1.064***	0.363	-2.93
TB	0.041***	0.010	4.24
LPCY	-3.845***	0.328	-11.72
Constant	40.753		
Error correction	-0.046***	0.012	-3.70
LM test for autocorrelation at lag 4	18.185 (0.313)		
Jacque-Bera	125.176 (0.000)		

These results suggest that money demand is increasing in nominal exchange depreciation and output per capita, while it is decreasing in Treasury bill rates. These results are plausible and are in line with theoretical expectations. According to our results, a one percentage depreciation of the exchange rate would result in a 1.064 percentage increase in money demand; a one percentage increase in real per capita output would result in a 3.845 increase in money demand; and a 1 percent increase in the opportunity cost of holding money would reduce money demand by 0.041 percent as economic agents substitute liquid assets for financial assets. Our results are consistent with among others: Kabundi (2012), Diouf (2007), and Nachenga (2001).

The LM test for autocorrelation fails to reject the null hypothesis of no autocorrelation indicating that our model suffers no autocorrelation. The Jacque-Bera test for normality, which is a joint test for skewness and kurtosis, rejects the null hypothesis of normality of the error structure. However, we do not worry much about the non-normal residual structure given the large sample properties of our estimation approach. The inverse roots of the characteristic polynomial indicate that the model is stable seeing that all roots locate within the unit circle (Appendix 2a).

4.2 The external sector

We follow Kinda (2011) who modeled the external sector using foreign prices and the exchange rate. This approach approximates a PPP relationship. We experimented with various international prices including the import price index, international price of crude oil, the terms of trade and, the international food price index. The international food price index yielded the best results for Uganda. Choice of the FAO index should not be a problem since the variables are highly correlated indicating that they carry the same information in the long-run. We thus modeled the external sector using the natural logarithm of core price index, the international food price index and the nominal exchange rate as shown in equation 14 below.

$$lcore_t = \beta_0 + \beta_1 lxrate_t + \beta_2 lfao_t + e_t \qquad 14)$$

The various lag selection criteria including the LR, FPE, AIC, HQIC and SBIC point to an optimal lag length of 2 as shown in table 6 below.

Table 6: lag length selection criteria for the external market

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	268.033				6.1e-06	-3.491	-3.463	-3.43
1	1199.56	1863.1	9	0.000	3.3e-11	-15.625	-15.53	-15.38
2	1244.94	90.763*	9	0.000	2.0e-11*	-16.10*	-15.93*	-15.68*
3	1253.09	16.289	9	0.061	2.1e-11	-16.09	-15.85	-15.49
4	1256.87	7.5551	9	0.580	2.2e-11	-16.02	-15.71	-15.24

The Johansen co-integration procedure does not reject the null hypothesis of one cointegrating vector (table 7). We are therefore confident that there could be one cointegrating relationship that explains the long-run equilibrium in the external sector.

Table 7: the Johansen tests for cointergration in the money market

Maximum rank	Number of parameters	LL	Eigen value	Trace statistic	5% critical value
0	12	1244.30		32.725	29.68
1	17	1257.44	0.16	6.437*	15.41
2	20	1260.40	0.04	0.531	3.76
3	21	1260.66	0.00		

The error correction term (ec_external) that represents the long-run disequilibrium in the external sector shows that there is a long-run relationship between core inflation, foreign prices, and nominal exchange rates. The long run relationship is shown in equation 14 and table 8 below.

$$ec_{external} = lcore_t - 0.909lxrate_t - 0.657lfao_t + 5.356 \quad 14)$$

Table 8: Long-run equilibrium in the external market

Variable names	Coefficient	Standard Error	Z value
LCORE	1		
LXRATE	-0.909***	0.121	-7.49
LFAO	-0.657***	0.051	-12.89
Constant	5.356		
Error correction	-0.046***	0.009	-4.97
LM test for autocorrelation at lag 2	11.029 (0.274)		
Jacque-Bera	180.224 (0.000)		

Results in the external sector suggest that the core price index is increasing in nominal exchange rate depreciation and the prices of imports. These results are in line with theoretical expectations and indicate that a one percentage depreciation of the nominal exchange rate would result in a 0.909 percentage increase in the consumer price index; and a one percentage increase in import prices would results in a 0.657 percentage increase in the consumer price index. These results are consistent with theoretical expectations and confirm earlier findings by Durevall et al (2013); Kinda (2011); and Diouf (2007).

The LM test for autocorrelation fails to reject the null hypothesis of no autocorrelation indicating that our model suffers no autocorrelation at the optimal lag length. However, the Jacque-Bera test for normality, which is a joint test for skewness and kurtosis, rejects the null hypothesis of normality of the error structure. The inverse roots of the characteristic polynomial indicate that the model is stable given that all roots locate within the unit circle (Appendix 3a).

4.3 The domestic agricultural sector

We model the agricultural sector using purely domestic factors that include domestic food crop inflation, agricultural output, and per capita GDP. In this model agricultural output is a measure of food supply and per capita GDP is a proxy for demand. We do not include any external variables such as the prices of imported food and the exchange rate. Our approach is plausible since food crop inflation in Uganda is computed using purely perishable domestic crop production without any value addition (see appendix 8). Value added agricultural products are included in core inflation.

Monthly data for agricultural production and per capita GDP are not available, so we interpolate quarterly series to arrive at the monthly data that we use in the model. It would be plausible to include the wages in the agricultural sector, but such data is not available for Uganda. In addition, it would be plausible to include data that capture the cost of inputs. However, such data is not available and may as well not be applicable to a country like Uganda where use of farm inputs and the adoption of agricultural technology is generally minimal as shown by Kasirye (2013). The estimated vector error correction model for the agricultural sector takes the form expressed in equation 15 below:

$$lfood_t = \beta_0 + \beta_1 lagric_t + \beta_2 lpcy_t + \varepsilon_t \qquad 15)$$

Where $lfood$ is the natural logarithm of food crop price index, $lagric$ is natural logarithm of domestic agricultural output, and pcy is the natural logarithm of output per capita. The various lag selection criteria including the LR, FPE, AIC, HQIC and SBIC point to an optimal lag length of 4 as shown in table 9 below.

Table 9: lag length selection criteria for the agricultural sector

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	272.255				5.8e-06	-3.542	-3.518	-3.483
1	804.821	1065.1	9	0.000	5.9e-09	-10.431	-10.334	-10.193
2	840.204	70.767	9	0.000	4.2e-09	-10.779	-10.609	-10.361
3	844.284	8.158	9	0.518	4.5e-09	-10.714	-10.471	-10.117
4	886.811	85.054*	9	0.000	2.9e-09*	-1.155*	-10.842*	-10.380*

The Johansen co-integration procedure as applied to the agricultural sector does not reject the null hypothesis of one cointegrating vector (table 10). We are therefore confident that there could be one cointegrating vector that explains the long-run equilibrium in the domestic agricultural sector.

Table 10: the Johansen tests for cointergration in the domestic agricultural sector

Maximum rank	Number of parameters	LL	Eigen value	Trace statistic	5% critical value
0	30	871.872		29.875	29.68
1	35	880.845	0.111	11.929*	15.41
2	38	885.883	0.064	1.853	3.76
3	39	886.810	0.012		

The error correction term (ec_agric) that represents the long-run disequilibrium in the agricultural sector shows that there is a long-run relationship between food crop inflation, domestic agricultural output and domestic fuel prices. This relationship is expressed as follows:

$$ec\_agric_t = lfood_t - 4.708lagric_t - 1.103lpcy_t + 32.849 \qquad 16)$$

Jacque-Bera test for normality, which is a joint test for skewness and kurtosis, rejects the null hypothesis of normality of the error structure. The inverse roots of the characteristic polynomial indicate that the model is stable as shown in appendix 4a.

4.4 The Energy sector

The energy, fuel and utilities (EFU) price index includes the prices of metered water,

Table 11: Long-run equilibrium in the agricultural sector market

Variable names	Coefficient	Standard Error	Z value
LFOOD	1		
LAGRIC	4.708***	1.178	4.00
LPCY	-1.103*	0.588	1.88
Constant	32.849		
Error correction	-0.082***	0.036	-3.24
LM test for autocorrelation at lag 4	6.682 (0.651)		
Jacque-Bera	3562.443(0.000)		

Results from the agricultural sector suggest that food prices are increasing in demand and decreasing in supply of food. This implies that more effective demand through higher incomes pushes food prices up while bumper harvests have a negative effect on prices. However supply factors seem to be more important in determining food prices in Uganda. Results suggest that a one percentage increase in agricultural production leads to a 4.708 percent reduction in the food price index, while a one percent increases in real income per capita results in a 1.103 percentage increase in the domestic food price index.

Robustness tests do not reveal any major problems with the model. The LM test for autocorrelation fails to reject the null hypothesis of no autocorrelation indicating that our model suffers no autocorrelation at the optimal lag length. However, the

electricity, petroleum products, including fuels and gas (see appendix 8 for breakdown of the CPI). However, the prices of metered water and electricity do not change frequently, as such we do not include them in our model. Uganda is currently highly dependent on imported petroleum products to meet its domestic energy demand. We therefore propose that disequilibrium in the energy markets is channeled through international prices of oil products and the exchange rate. We estimate the long run equilibrium in the domestic energy markets, using vector error correction techniques, following the equation 17 below:

$$lefu_t = \beta_0 + \beta_{1l}lcrude_t + \beta_2 lxrate_t + \varepsilon_t \qquad 17)$$

Where $lefuefu$ is the natural logarithm of the EFU price index, *crude i*s the natural logarithm of international price for a barrel of crude oil, and *xrate* is the natural logarithm of real effective exchange rate. As before, variables are included in their natural logarithm transformations. The various lag selection criteria including the LR, FPE, and AIC indicate that the optimal lag length for the energy market is 2 as shown in table 12.

The Johansen co-integration procedure as applied to the energy market for Uganda sector rejects the null hypothesis of cointergration (table 13). As such we do not continue with the estimation of the long run long-run equilibrium in the domestic energy market.

4.5 The single equation inflation model results

Results from the single equation inflation model (table 15) indicate that disequilibria in the money, external and domestic agricultural sectors are inflationary. The adjustment coefficients (equilibrium correction) are -0.036 -0.039 and -0.020 respectively indicating that 3.6 percent, 3.9 percent and 2.0 percent of all disequilibria in the money external, and agricultural sectors are corrected in the following month. These results highlight the significance of monetary, external and agricultural supply shocks in Uganda's inflation processes.

Table 12: lag length selection criteria for the energy

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	135.485				3-5e-05	-1.743	-1.718	-1.68354
1	818.547	1366.1	9	0.000	4.9e-09	-10.612	-10.515*	-10.3737*
2	829.909	22.725*	9	0.007	4.8e-09*	-10.643*	-10.473	-10.2258
3	837.553	15.288	9	0.083	4.9e-09	-10.626	-10.383	-10.0289
4	839.052	2.997	9	0.964	5.4e-09	-10.527	-10.211	-9.75114

Table 13: the Johansen tests for cointergration in the domestic energy sector

Maximum rank	Number of parameters	LL	Eigen value	Trace statistic	5% critical value
0	12	842.216		21.499*	29.68
1	17	850.870	0.106	4.191	15.41
2	20	852.931	0.026	0.070	3.76
3	21	852.966	0.000		

Table 15: The Uganda Inflation model

Dependent Variable: differenced natural logarithm of the CPI (Δ LCPI)			
independent variables	coefficient	standard error	t value
Inflation inertia			
Δ LCPI (t-1)	0.163***	0.054	2.99
Δ LCPI (t-3)	0.183***	0.050	3.60
Δ LCPI (t-6)	0.147***	0.048	3.05
Δ LCPI (t-9)	-0.114**	0.045	-2.55
Δ LCPI (t-12)	0.149***	0.046	3.24
National output per capita			
Δ LPCY (t-1)	0.153**	0.062	-2.47
Δ LPCY (t-6)	0.185***	0.060	3.07
Δ LPCY (t-12)	-0.264***	0.071	-3.71
Nominal exchange rate			
Δ LXRATE (t-1)	0.094***	0.033	2.85
Δ LXRATE (t-9)	0.075**	0.032	2.37
Money supply			
Δ LM2 (t-2)	0.067**	0.029	2.37
Δ LM2 (t-5)	-0.061**	0.028	-2.23
Δ LM2 (t-7)	-0.072**	0.029	-2.46
Δ LM2 (t-10)	0.077**	0.031	2.49
Agricultural Output Gap			
GAP (t-1)	-0.004**	0.000	-1.98
GAP (t-10)	-0.005**	0.000	-2.34
GAP (t-11)	0.008***	0.000	2.93
GAP (t-12)	-0.004**	0.000	-2.15
Treasury bill rates			
TB (t-8)	-0.0010**	0.000	-2.07
TB (t-12)	-0.0012***	0.000	-2.76
Dummy variables			
Quarter three dummy	0.0132***	0.002	5.13
Error Correction terms			
EC – Money Market (-1)	-0.0368***	0.011	-3.22
EC – External market (-1)	-0.039	0.015	-5.85
EC – Agricultural market (-1)	-0.019	0.012	-5.47
Constant	-0.003*	0.001	-1.79
R-Squared	0.600		
Adjusted R-Squared	0.523		
Durbin Watson	2.026		
Normality	4.53 (p=0.104)		

The results indicate significant inflation inertia in the short-run. Lagged inflation enters the short-run model positively and is significant in the first, third, sixth, ninth and twelfth lags indicating significant inflation inertia in the Uganda inflation processes.

The agricultural output gap, included to capture the short-run impact of agricultural supply shocks to inflation, is an important source of inflation in the short-run. An increase in production that raises agricultural supplies by 10 percent above its mean trend level reduces the consumer price index by four hundredths of a percentage point in the following month. This effect is large considering the units of measurement involved and, as expected, indicates the importance of agricultural supply shocks in explaining Ugandan inflation. The inflationary effects of a shock in agricultural output persist for one calendar year and are significant in the first, tenth, eleventh and twelfth months. This result is similar to earlier findings by Adam et al (2012) for Tanzania, Kinda (2011) for Chad, Diouf (2007) for Mali and Durevall et al (2013) for Ethiopia.

National per capita output affects inflation with a one month lag. A 10 percent increment in output per capita increases the consumer price index by 1.5 percentage points in the following month. The effect of output per capita persists for a full year and is significant in the first, sixth and twelfth months. Higher national output per capita affects inflation through its effect on demand.

Nominal exchange rate movements affect inflation with a one month lag. Results indicate that a 10 percent depreciation (or appreciation) of the nominal exchange rate increases (or decreases) the consumer price index by nine-tenths of a percentage point in the following month. The effect of the exchange rate on the domestic inflation is through the increased prices of imports. The inflationary effects of exchange rate shocks persist up to the 9th month and are significant in the first and ninth months.

Money supply enters the inflation equation positively in the first month indicating that increasing money supply is inflationary in the short-run. Results indicate that a 10 percent increment in money supply results in an increase in the consumer price index of two-thirds of a percentage point with a two month lag. The effect of money supply on the consumer price index persists for 10 months, and is significant in the second, fifth, seventh and tenth months.

Changes in the Treasury bill rates, which measure the opportunity cost of holding cash balances but are also the monetary policy instruments used to regulate money demand affect inflation with an eight month lag. The coefficient on the sixth lag of the treasury bill rates is negative indicating that higher treasury bill rates lower inflation in the short-run. The effect of treasury bill rates persist through the twelfth month.

The coefficients on the dummy variable for the global financial crisis and inflation targeting regime were not significant in the parsimonious model, and were therefore dropped. However, quarterly seasonal dummies indicate that inflation is on average higher in the third quarter of the calendar year.

The single equation model predicts inflation well. Appendix 5 shows that the in-sampleforecasting (predicted values) fits the actual dependent variable pretty well. The residuals as shown in appendix 6 above are approximately normally distributed. The possibility of omitted variable bias in our model is therefore not a major concern.

4.6 The Vector Auto Regressive (VAR) Model

Our VAR treats international prices of fuel as exogenous to the model. All other variables are treated as endogenous. In estimating the VAR various lag selection criteria including the FPE, AIC and HQ indicate an optimal lag length of 5 as shown in table 16 below:

Table 16: Lag length selection criteria for the VAR model

Lag	LL	LR	FPE	AIC	SC	HQ
1	792.73	1807.81	1.72e-12	-10.06	-9.09	-9.66
2	916.59	224.29	5.25e-13	-11.25	-9.55*	-10.56
3	971.07	94.23	4.12e-13	-11.50	-9.07	-10.51
4	1046.39	124.17	2.45e-13	-12.03	-8.87	-10.74
5	1116.25	109.50	1.58e-13*	-12.49	-8.60	-10.91*

The LM test for autocorrelation fails to reject the null hypothesis of no autocorrelation indicating that our model suffers no autocorrelation. The Jacque-Bera test for normality, which is a joint test for skewness and kurtosis in the residual processes, rejects the null hypothesis of normality of the error structure. However, as explained earlier, we do not worry much about the non-normal residual structure given the large sample properties of our estimation approach. The inverse roots of the characteristic polynomial indicate that the model is stable seeing that all roots locate within the unit circle (Appendix 7).

4.6.1 Pair wise Granger Causality tests

The pair-wise Granger causality Wald tests were carried out to identify the endogenous factors that are important for Uganda's inflation processes. A variable, say X, is said to Granger cause another variable, say Z, if, given the past information or values of Z, past values of X are useful in predicting Z (Granger 1969). A convenient way for testing Granger causality is to regress X on its owned lagged values and on lagged values of Z and test for the joint significance of the estimated coefficients on Z.

Results in table 17 indicate that: First, the consumer price index (CPI) Granger causes exchange rates and the relationship is unidirectional. Second, CPI Granger causes money supply, but money supply does not Granger cause CPI. Third, treasury bill rates Granger causes CPI and the relationship is bidirectional implying that CPI Granger causes treasury bill rates. Fourth, neither do per capita GDP and the agricultural output gap Granger cause CPI nor does CPI Granger cause them. These results point to the strong role that monetary policy has to play in controlling inflation in Uganda, given the bidirectional causality between treasury bill rates and the consumer price index.

Table 17: Pair wise Granger non-causality tests for the CPI

Null hypothesis	Chi-square	P-value	Conclusion
Per capita output does not Granger cause CPI	6.659	0.247	Accept
CPI does not Granger cause per capita output	5.339	0.376	Accept
Exchange rate does not Granger cause CPI	8.588	0.127	Accept
CPI does not Granger cause exchange rate	33.929	0.000	Reject
Money supply does not Granger cause CPI	6.839	0.127	Accept
CPI does not Granger cause money supply	11.521	0.042	Reject
Treasury bill rates do not Granger cause CPI	18.223	0.003	Reject
CPI does not Granger cause treasury bill rates	27.486	0.000	Reject
Agricultural output gap does not Granger cause CPI	0.557	0.990	Accept
CPI does not Granger cause agricultural output gap	3.692	0.595	Accept

4.6.2 Impulse response functions

Results presented in figure 4 show that a one standard deviation positive shock in per capita GDP pushes up inflation and the effect persists for eight months. The impact of per capita GDP on inflation is at its maximum four months after the shock. The VAR impulse response functions highlight that the effect of per capita GDP is persistent. The effect of per capita GDP on inflation is probably through its effect on effective demand since per capita incomes are likely to increase with per capita output.

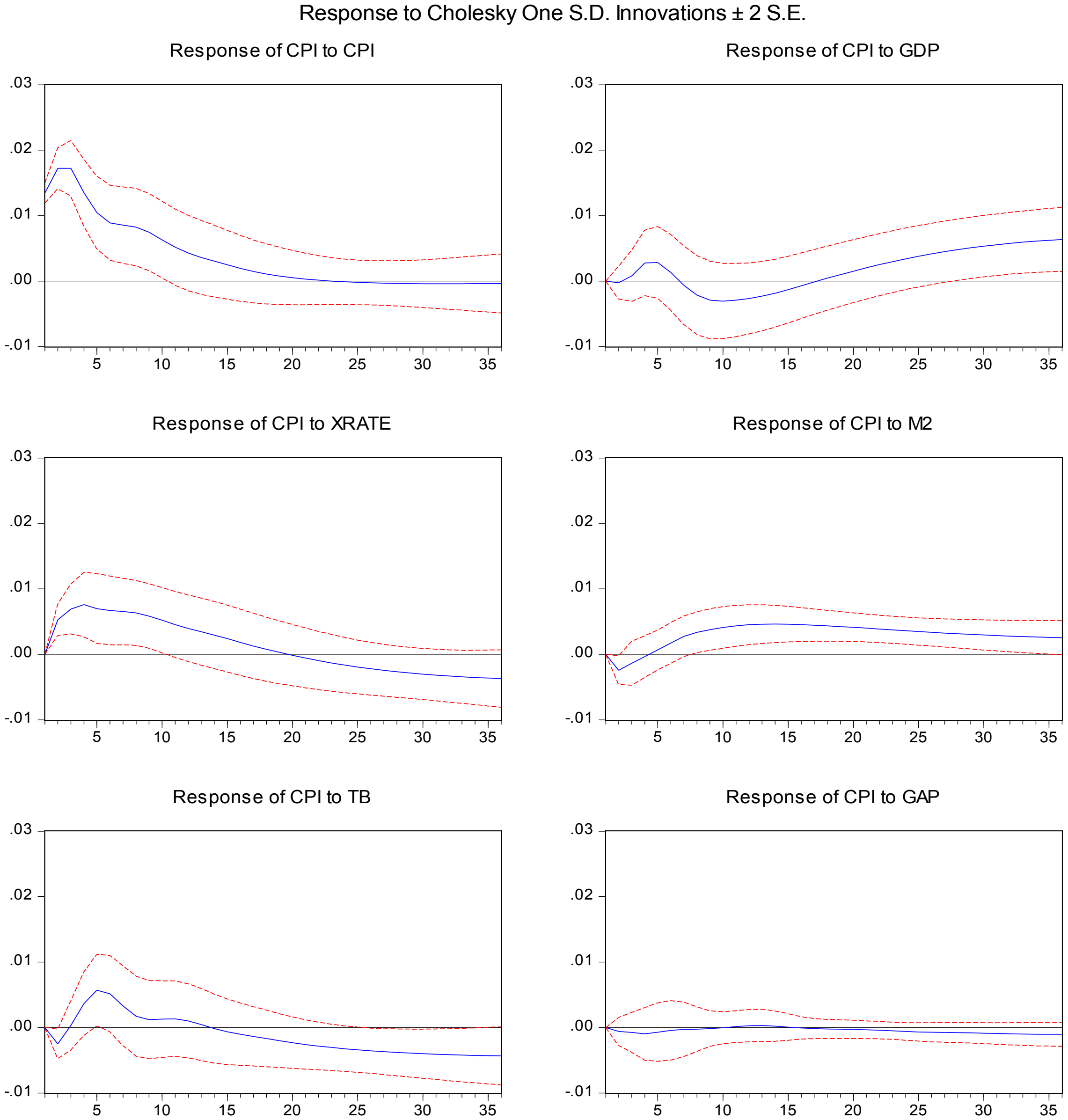
A positive shock in nominal exchange rates pushes up inflation during eight months. The impact of nominal exchange rate depreciation is at its maximum four months after the shock, confirming the result of the single equation model. The VAR impulse response function highlights that the effect of per capita nominal exchange rate depreciation on the CPI is transitory. Exchange rate depreciation raises the CPI between the first and eighth months. The impact increases between the first and fourth month, reaches its maximum during the fourth month and decreases gradually until it becomes insignificant in the eighth month.

A positive shock in nominal money supply pushes up inflation during the first thirty six months. The impact of money supply is at its maximum twelve months after the shock, confirming the result of the single equation model. The VAR impulse response function highlights that the effect of money supply on the CPI is persistent. Money supply raises the CPI between the first and twelfth months, reaches its maximum after which it starts to decline until it becomes insignificant after the twenty fourth month.

A positive shock in treasury bill rates reduces inflation during the first six months. The impact of a shock on treasury bill rates reaches its maximum in the third month after which it gradually dies out by the sixth month.

A positive shock to the agricultural output gap reduces the CPI during the first six months. The impact of increased agricultural supply that positively shocks the output gap is at its maximum three months after the shock, confirming the result of the single equation model. The VAR impulse response function highlights that the effect of the agricultural output gap is persistent and decreased the CPI between the first and

Figure 4: Impulse responses of CPI



sixth months, reaching its maximum three months after which starts to decline until it becomes insignificant after the sixth month.

4.6.3 The role for monetary policy

We investigate if monetary policy has a role to play in inflation that is among other things caused by agricultural supply shocks. In this respect, we investigate how the monetary policy variable, the treasury bill rate, interacts with other variables in the VAR framework. Specifically, we examine Granger causality tests (table 18) and impulse response functions (figure 5). Our particular interest is to investigate if monetary policy can affect the agricultural output gap and other endogenous variables included in the model.

Results from the Granger causality tests suggest, as expected, that there exists a bidirectional relationship between treasury bill rates and the consumer price index. Further, results show that treasury bill rates

Granger cause the agricultural output gap. This result is interesting, but consistent with findings by Nampewo et al (2013) who show that the agricultural sector is responsive to monetary policy shocks.

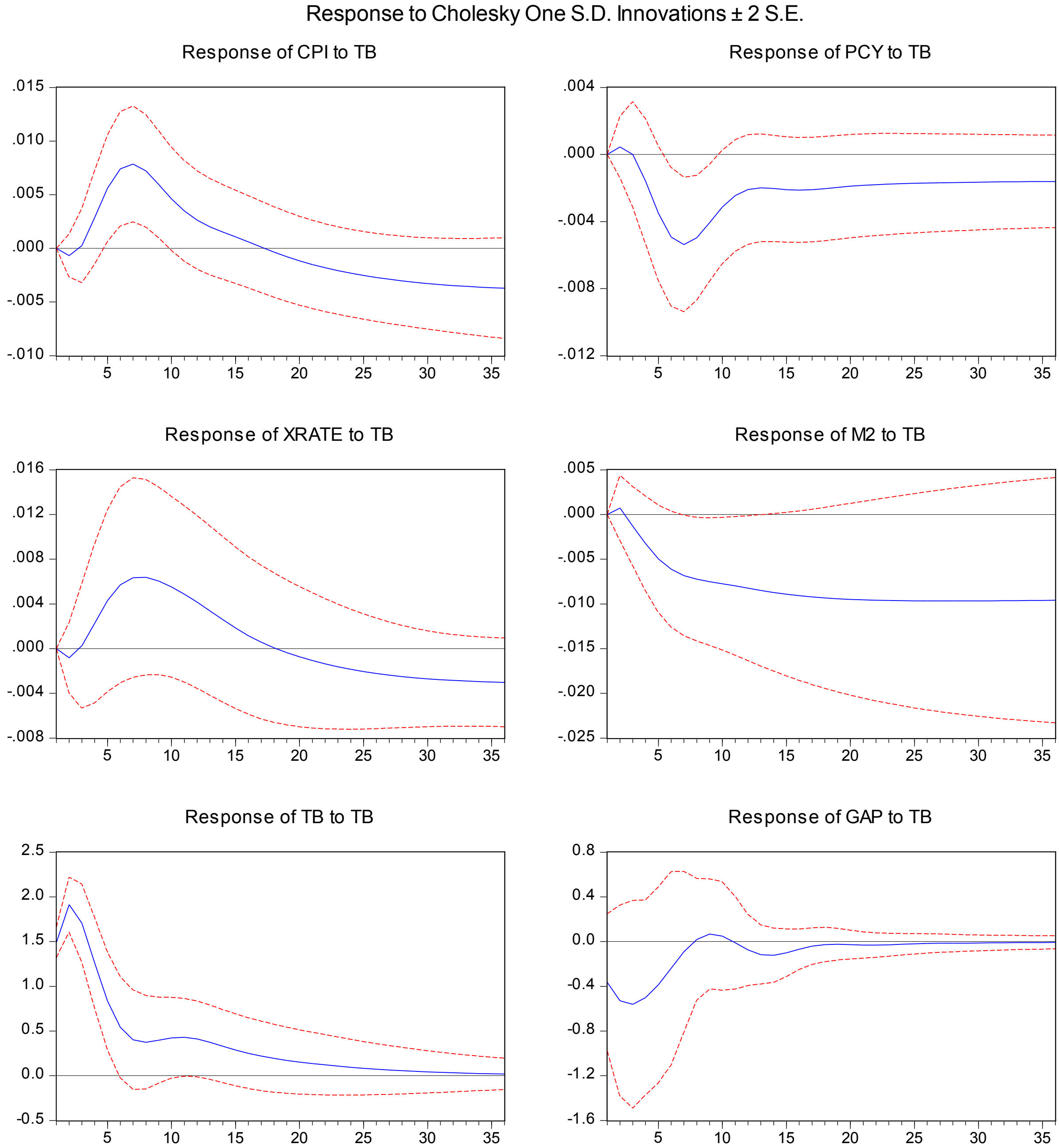
In addition, impulse response functions (figure 5) show that, among others, a one standard deviation positive shock in treasury bill rates results into a reduction in agricultural GDP and thus widen the agricultural output gap. The full effect of the response of agricultural output gap to a shock in treasury bill rates take full effect after three months.

These results suggest that there is scope for monetary policy to supplement fiscal policy by promoting the growth and expansion of the productive sectors, including agriculture. Indeed, monetary policy that encourages lending to the agricultural sector would help to smooth the effects of various shocks in the sector thereby keeping any inflationary effects in check.

Table 18: Pair wise Granger non-causality tests for the treasury bill rate

Null hypothesis	Chi-square stat	P-value	Conclusion
TB does not Granger cause CPI	18.223	0.003	Reject
CPI does not Granger cause TB	27.486	0.000	Reject
TB does not Granger cause per capita GDP	5.086	0.405	Accept
Per capita GDP does not Granger cause TB	8.554	0.128	Accept
TB does not Granger cause exchange rates	5.318	0.378	Accept
Exchange rate does not Granger cause TB	6.105	0.296	Accept
TB does not Granger cause money supply	5.096	0.404	Accept
Money supply does not Granger cause TB	6.748	0.240	Accept
TB does not Granger cause agricultural output gap	10.141	0.071	Reject
Agricultural output gap does not Granger cause TB	7.701	0.173	Accept

Figure 5: Impulse responses to shocks in Treasury Bill Rates



5. CONCLUSIONS AND POLICY RECOMMENDATIONS

In this paper, we developed an empirical model for inflation in Uganda, highlighting the role of supply side factors in the domestic agricultural sector. The adopted empirical analysis is based on a single equation model augmented by a VAR model to account for inflation persistence. The analysis controls for seasonal, historical, as well as policy factors such as the effects of the global financial crisis and the change in monetary policy regime to inflation targeting. We include the agricultural output gap in our model to control for agricultural supply shocks. Results indicate that disequilibria in the money, external and agricultural sectors feed into the Ugandan inflation process in the long run.

Importantly for this paper, the agricultural output gap has a statistically significant effect on inflation in the short run. An increase in agricultural production that reduces the agricultural output gap reduces inflation within one month. Other factors that influence inflation in the short run include: inflation inertia, per capita output, money supply, exchange rate movements, and monetary policy instruments.

Moreover, the Granger causality tests and impulse response functions estimated from the VAR show there is scope for monetary policy to supplement fiscal policy by promoting the growth and expansion of the productive sectors, such as agriculture. Indeed, monetary policy that encourages lending to the agricultural sector would help to smooth the effects of various shocks in agriculture thereby keeping any inflationary effects in check.

The inflationary effects of agricultural supply shocks could be mitigated with appropriate domestic policy actions. In particular, fiscal policy that targets increased productivity and efficiency in agriculture through increased focus on: irrigation, storage and could reduce the effects of agricultural supply variability on inflation. In addition, policies intended to improve economic growth by expanding total output, control money supply growth and maintaining stability in the foreign exchange markets will help to reduce inflation.

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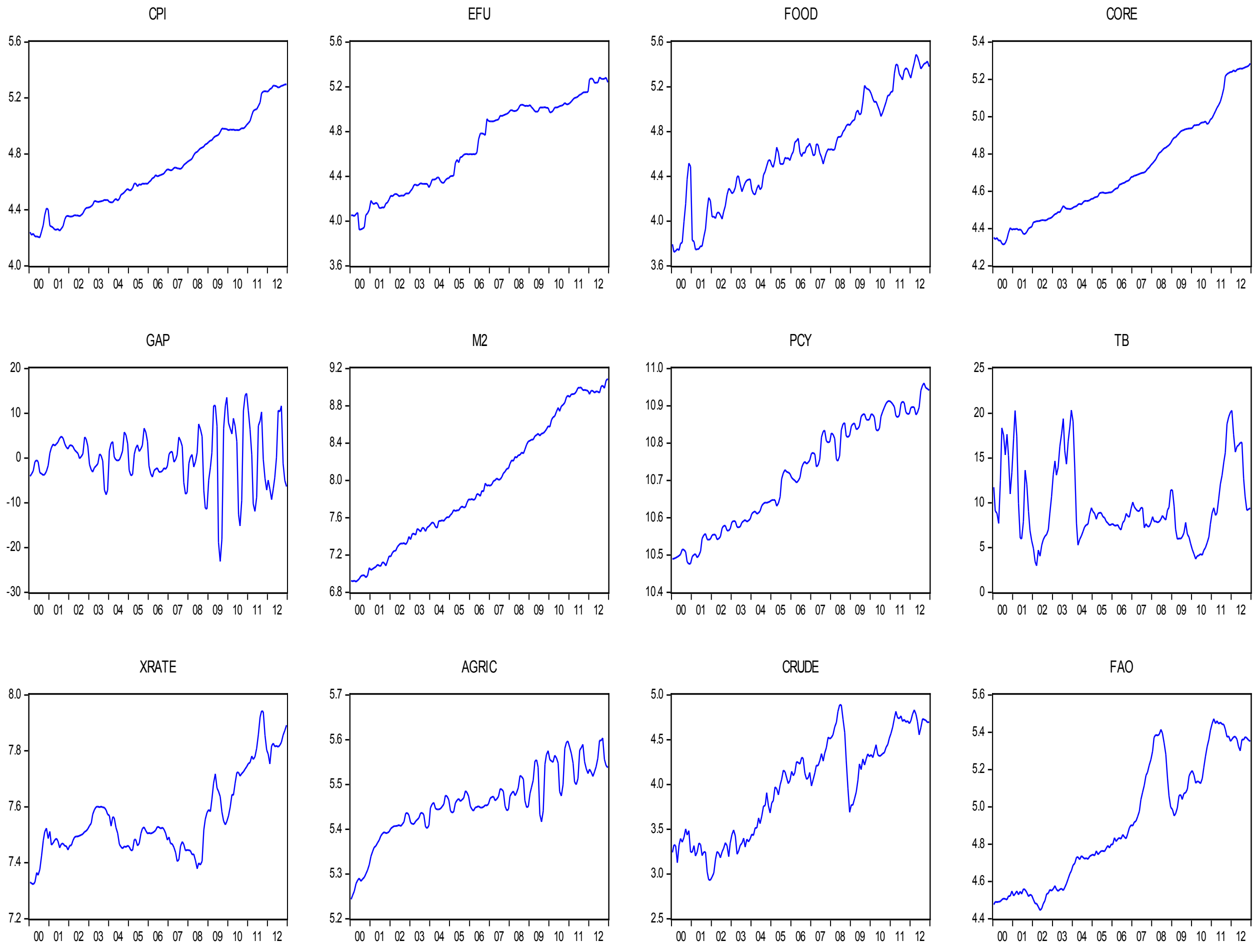
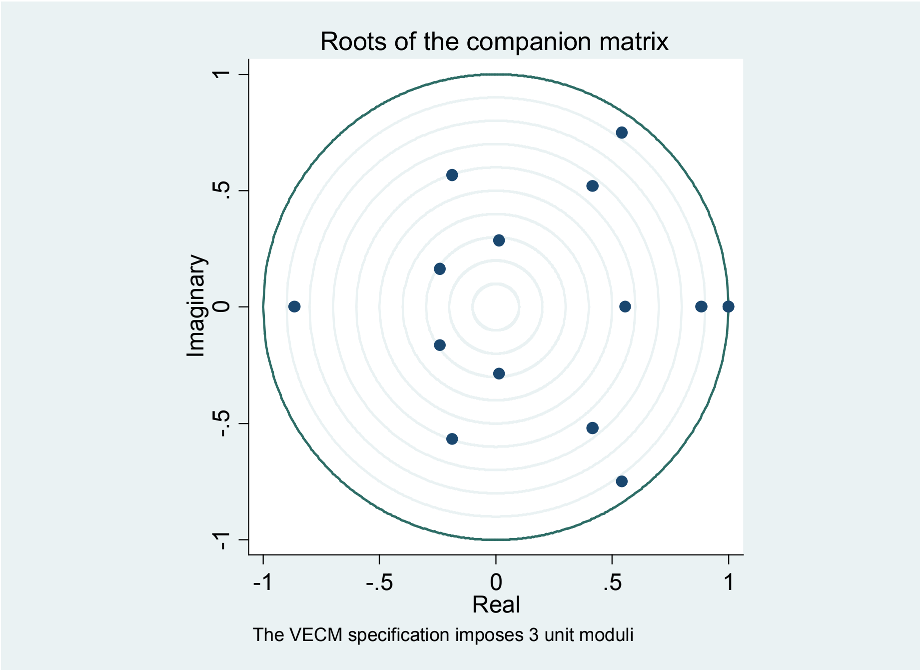
APPENDICES

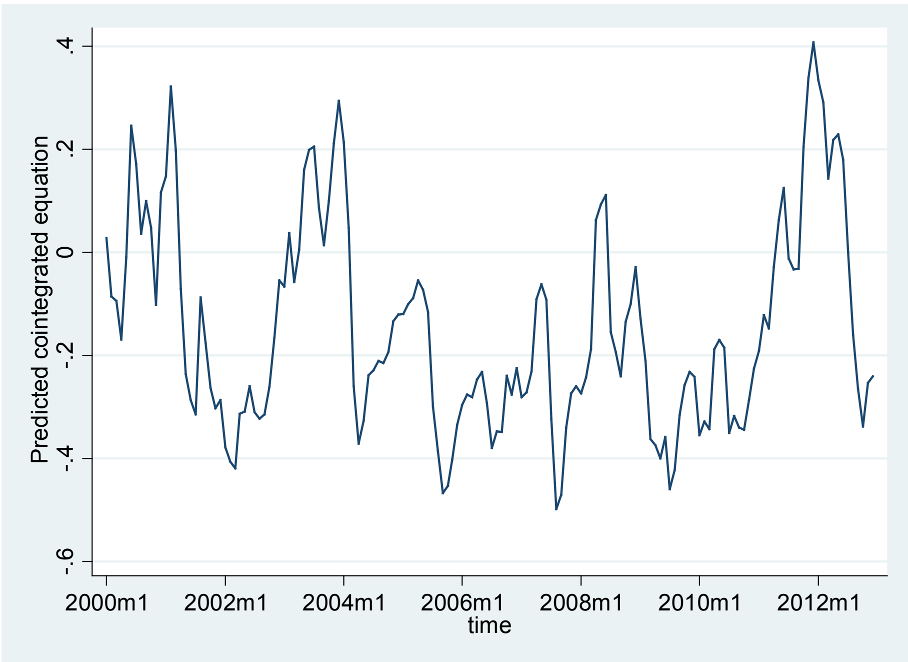
Appendix 1: Graphical exposition of the data



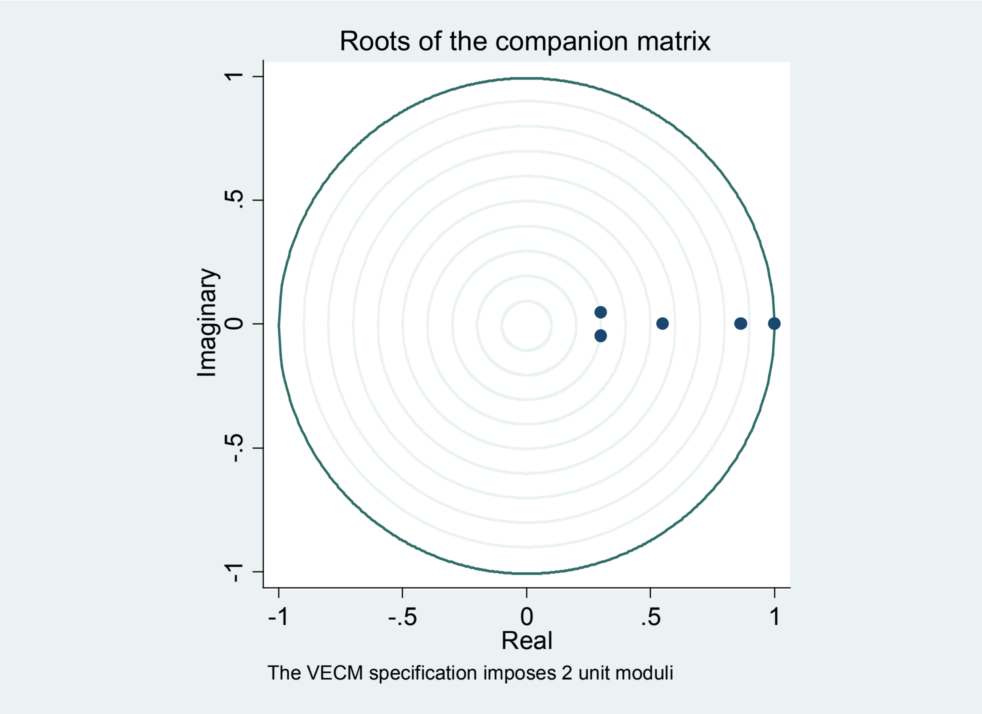
Appendix 2a: The characteristic polynomial roots for the money market



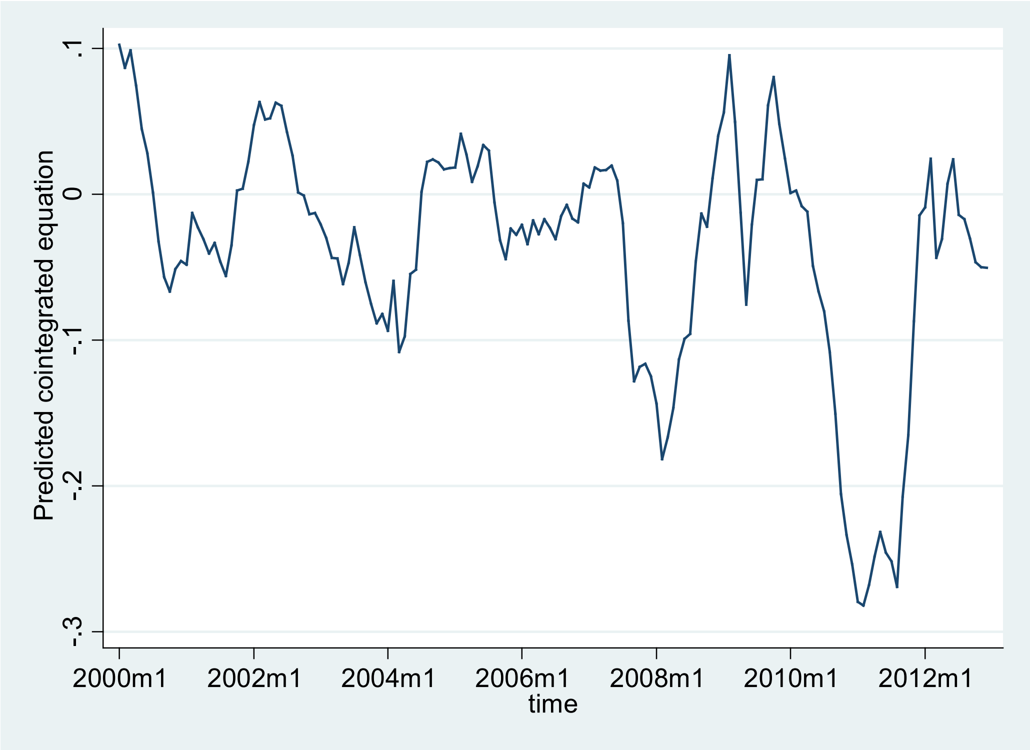
Appendix 2b: The long-run money market relationship



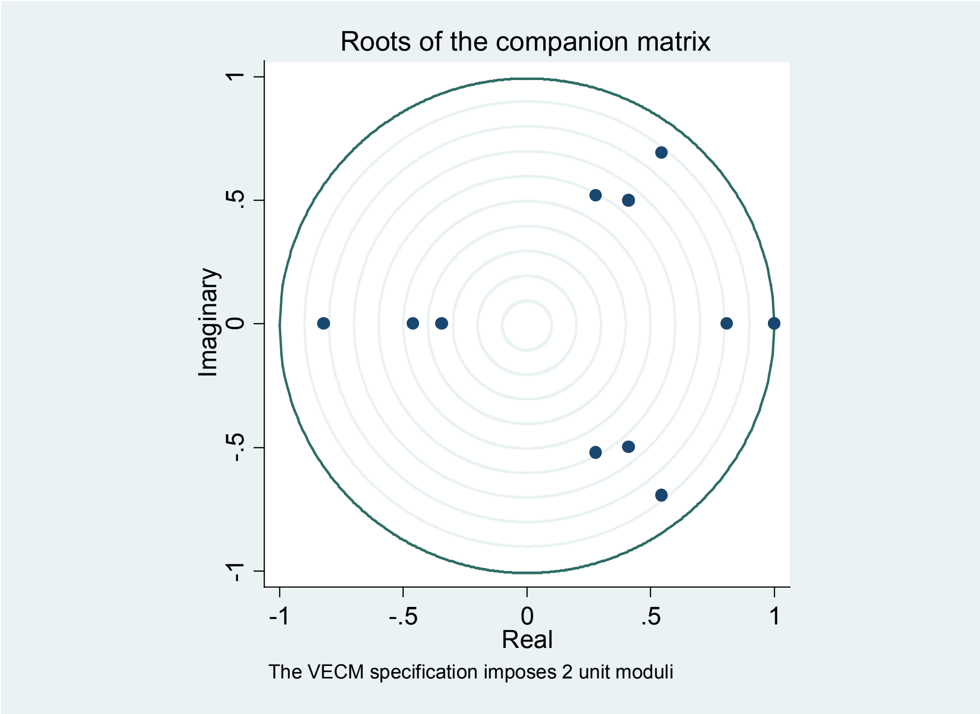
Appendix 3a: The characteristic polynomial roots for the external market



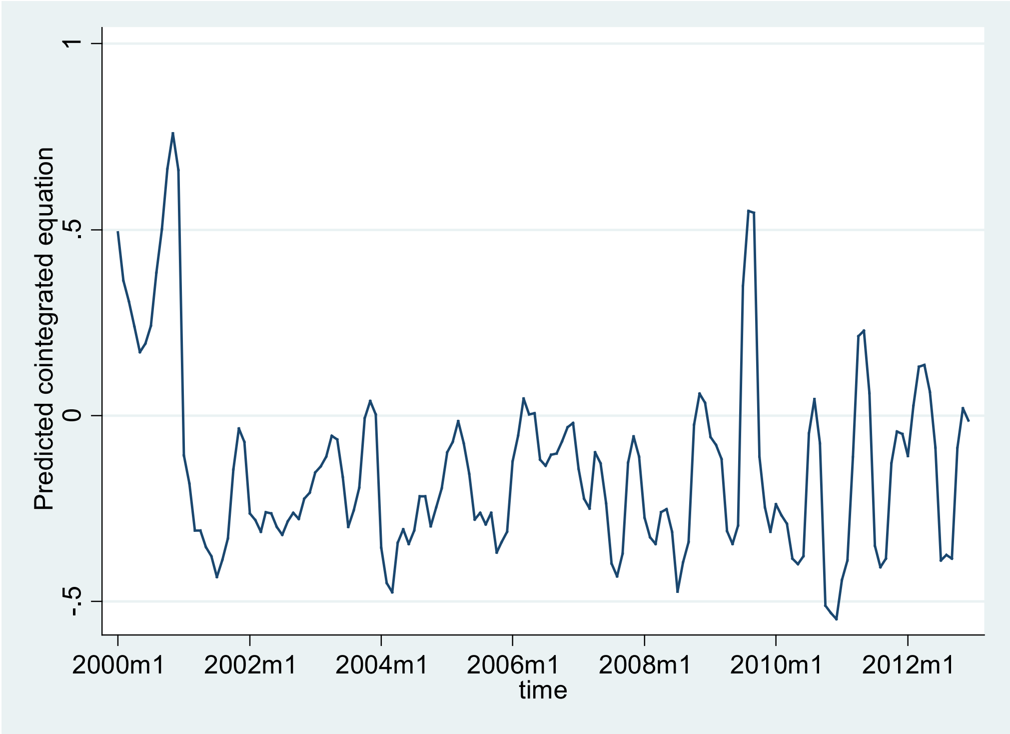
Appendix 3b: The long-run external market relationship



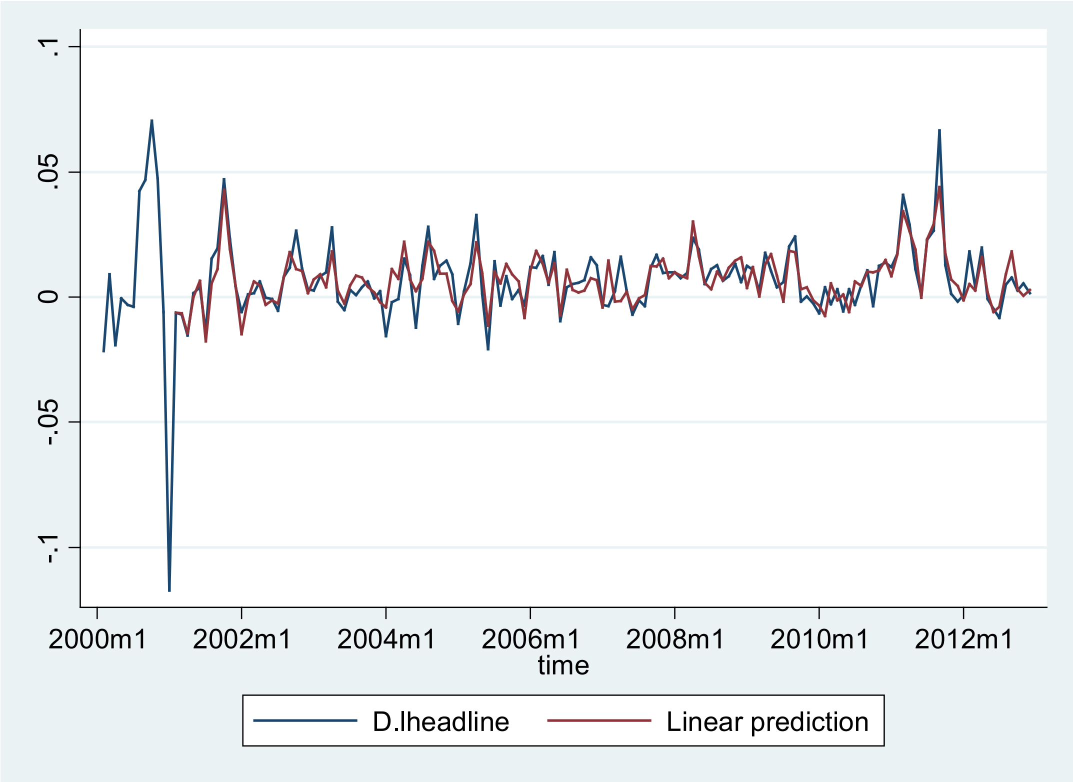
Appendix 4a: The characteristic polynomial roots for the agricultural market



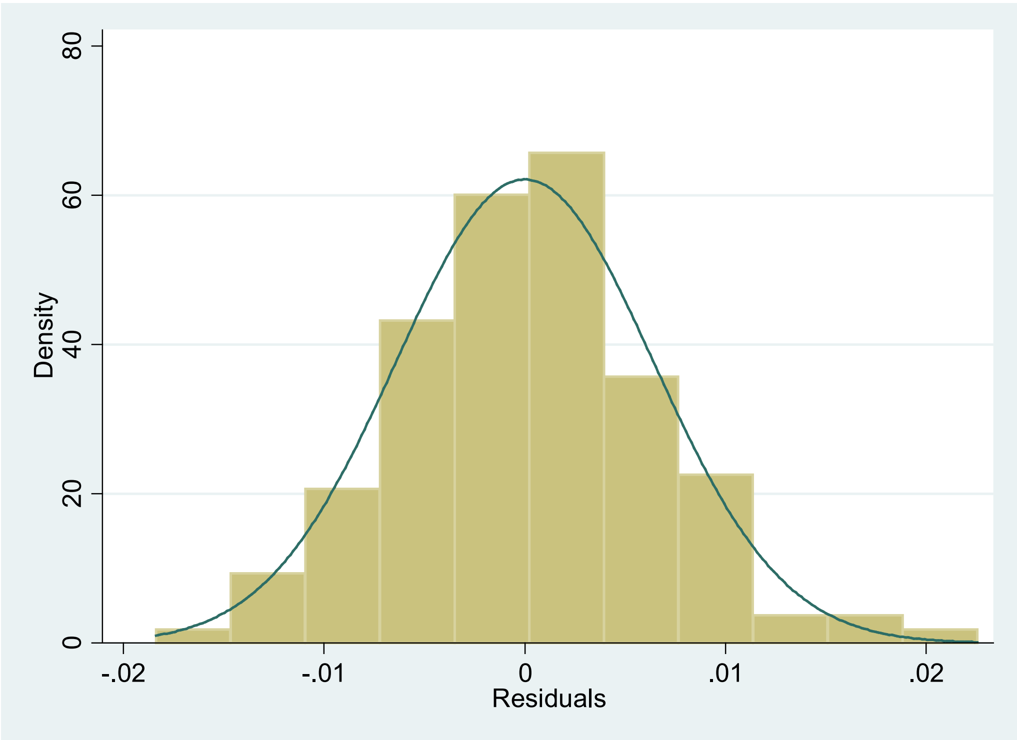
Appendix 4b: The long-run agricultural sector relationship



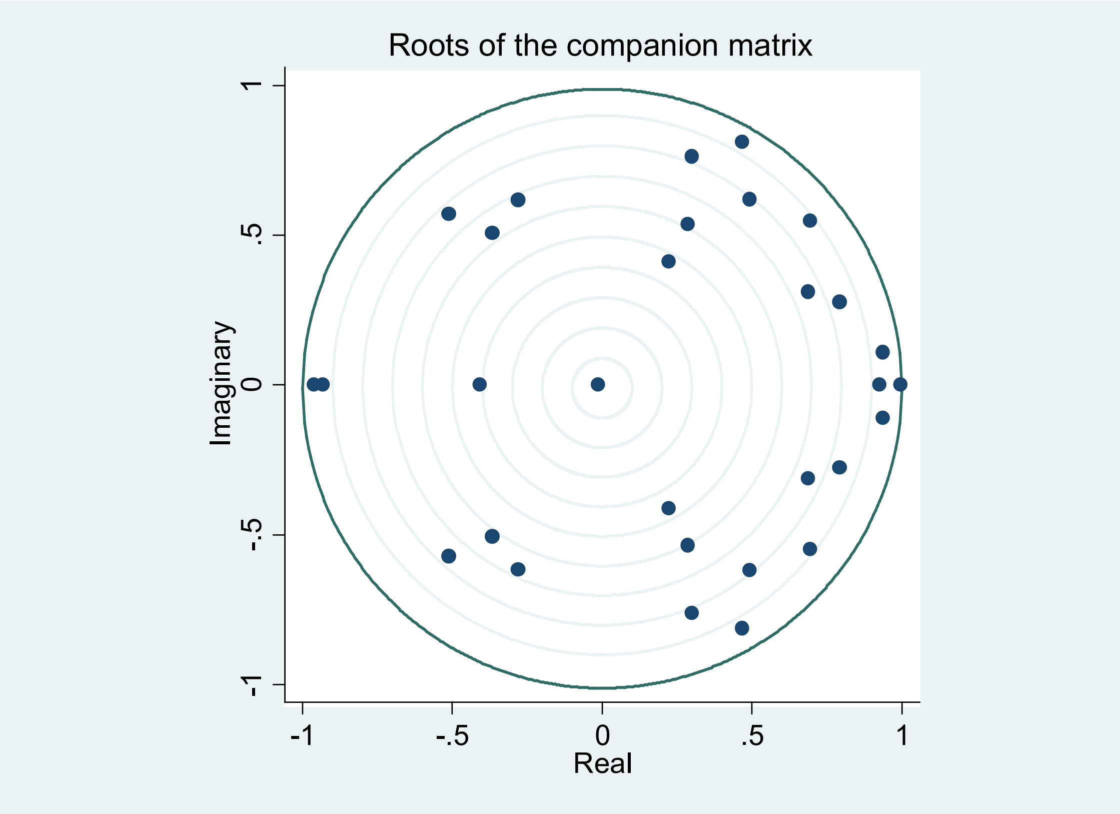
Appendix 5: Actual and predicted values of the dependent variable



Appendix 6: Histogram Plot of the single equation inflation residuals



Appendix 7: The characteristic polynomial roots for the VAR model



Appendix 8: The breakdown of the CPI and its components

CORE	FOOD CROPS AND RELATED ITEMS	ENERGY, FUEL AND UTILITIES
Processed cassava, dried beans, ground nuts, peas, rice, grains flour	Matooke (clusters and bunches), Banana (ndizi and bogoya)	Electricity, metered water
Meat, chickens, eggs. Fish, processed milk	Fresh potatoes (irish and sweet), fresh cassava	Kerosene, paraffin, motor fuel (petro and diesel)
Soft drinks, alcoholic drinks, tobacco	Fruits (passion, mangoes, oranges, water melon, pineapples, papaya and avocado)	Propane gas
Clothing, footwear, domestic fuel, soap	Vegetables (tangerines, onions, garlic, tomatoes, cabbage, carrots, green paper, egg plant, pumpkin, fresh beans, fresh peas, bbugga, nakati, etc	
Rent, building materials, furniture	Fresh milk	
Transport fares, education costs, health goods and servicesm communication services, hotel and restaurant services and hairdressing	Cassava (dry fermented)	
Electrical and electronics	Tobacco leaves	

CORE	FOOD CROPS AND RELATED ITEMS	ENERGY, FUEL AND UTILITIES
**The respective contributions of core, food crop and energy fuel and utilities (EFU) inflation to headline inflation in Uganda are: 81.63%, 13.45%, and 4.92%.		

Source: Mukiza, C.N. (2011)

Appendix 9: Definition of variables

Variable names	Definition
LCPI	Natural logarithm of the consumer price index
LCORE	Natural logarithm of the core price index
LFOOD	Natural logarithm of the food crop price index
LEFU	Natural logarithm of the energy, fuel and utilities price index
LPCY	Natural logarithm of the per capita gross domestic product (GDP)
LXRATE	Natural logarithm of the nominal exchange rate
LM2	Natural logarithm of money supply, measures as M2
GAP	The agricultural output gap, measured as deviations of realized from potential agricultural production
TB	91-day treasury bill rates – a measurement of opportunity cost of holding money and monetary policy stance
LCRUDE	The natural logarithm of international fuel prices measured as the cost of a barrel of crude oil
LFAO	The natural logarithm of the international food price index as computed by FAO
LAGRIC	Natural logarithm of realized agricultural output
DQ2	Seasonal dummy variable =1 for 2nd calendar quarter
DQ3	Seasonal dummy variable =1 for 3rd calendar quarter
DQ4	Seasonal dummy variable =1 for 4th calendar quarter
IT	Dummy variable =1 for time periods after the implementation of the inflation targeting policy change
GFC	Dummy variable =1 for time periods after the global financial crisis

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